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ABSTRACT

This study examined the influence of reflective journal writing, paired with inquiry-based science instruction, on preservice elementary teachers' beliefs about science and science teaching. Participants actively interacted with scientific ideas and phenomena in class. They kept daily reflection journals, reacting to statements from various educational standards. Feedback was provided via discussion groups and written responses from the professor. Students completed the Science Teaching Efficacy Belief Instrument. Researchers used data from the surveys, student journals, observations, lesson plans, and discussions to analyze emergent themes (students' perceptions about science, their ability to teach science, and who can learn science). Reflective journal writing influenced student teachers' beliefs and attitudes toward science and science teaching. Students made connections between reaction statements and state science teaching competencies. The inquiry-based environment allowed students to contemplate their beliefs about their own competency and understanding of science and science teaching. Students came to believe that science could be fun and interesting to students and teachers and that science should be an important part of elementary students' learning. The experiences in class increased their own science content knowledge, and they felt more confident to modify lessons done in class for K-8 students. (Contains 25 bibliographic references.) (SM)

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REFLECTIVE JOURNAL WRITING IN AN INQUIRY-BASED SCIENCE COURSE FOR ELEMENTARY PRESERVICE TEACHERS

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REFLECTIVE JOURNAL WRITING IN AN INQUIRY-BASED SCIENCE COURSE FOR ELEMENTARY PRESERVICE TEACHERS

INTRODUCTION

Why do elementary education majors take science courses during their undergraduate degree work? If any natural science courses are required, generally, science laboratory courses are taken only to fulfill this requirement. The perspective that science is a subject they will eventually teach in the elementary classroom seems to be a cognitive construct of a limited number of these pre-service teachers. How can the instructional leadership role provided in undergraduate science course work be enhanced to address this issue?

During validation of the STEBI-B, a form of the Science Teaching Efficacy Belief Instrument that measures current beliefs and attitudes and some predictions of future abilities and attitudes of pre-service teachers, Enochs and Riggs (1990) identified lack of strong science content background and lack of instructional leadership among factors that affected elementary science teaching.

The STEBI-B was used in selected Australian schools to assess changes in pre-service elementary science teachers' efficacy beliefs (Ginns & Watters, 1998; Ginns, Watters, Tulip & Lucas, 1995). They suggest that pre-service teachers' attitudes and beliefs about science teaching are greatly influenced by their personal experiences in learning science.

The STEBI-B was used along with the Draw-A-Science-Teacher Test to investigate perceptions elementary pre-service students had of themselves as science teachers and whether course work could improve their perceptions (Thomas, Pedersen, & Bonstetter, 1998). Their

findings were similar to previous studies about pre-service teachers' beliefs regarding science teaching and who can learn science.

The previously mentioned studies each show evidence of concern for the role of instructional leadership in college science courses. Not only must stereotypical beliefs about elementary science and science teaching be deconstructed, but these must be replaced with a belief system of confidence and conceptual understanding. This exploratory study investigated the influence of reflective journal writing, paired with inquiry-based science instruction, as a component on pre-service teachers' beliefs about science and science teaching.

RATIONALE

Reflective journal writing is becoming a common practice in teacher education as a means of directing pre-service teachers' focus on the context and experiences of their own teaching and learning. Issues often found in these writings include summaries and descriptions of learning incidents and experiences, analysis and interpretation of events, connections between events and prior knowledge, and implications for future teaching/learning contexts (Centre for Academic Practice, 2000).

With the advent of systemic reform in education and advances in cognitive learning theory, much attention is being paid to higher order thinking and problem-solving at all levels of schooling (Benchmarks, 1993; David, 1994; Herman, 1994; Means, et al, 1993; NCTM, 1989; NSES, 1996; Pogrow, 1990).

According to Ericsson and Charness (1994) supervised practice begins at an early age and continues over ten years or more in the achievement of astute performance. This would suggest that early engagement (in the primary and intermediate grades) in active observation, critical thinking, and problem solving has the potential to build confidence in science learning among all

children. Raised confidence and routine engagement in science learning has the possibility of causing a ripple effect. These effects may help determine future course choices and greater access to higher-level science and mathematics classes at the secondary level, in higher education, equity in opportunity for increased quality in daily living, and for viable career choices in the science and mathematics professions. (Bell & Eaton, 2000).

In a 1999 study of the first year of a three-year professional development program for elementary teachers, Mathematics and Science Education Cooperative (MSEC), it was discovered that a complex of interrelated factors influenced the participants' attitudes and teaching practices. Among those factors were university leadership and support, science content, process skills, and pedagogical skills knowledge, and management of time, curriculum, and children. Collaboration was a mediating factor. When the participants were actively engaged in learning science content and teaching skills in an environment supported by the university leadership, the in-service teachers were more likely to increase their confidence and attempt inquiry-based science instruction in their classrooms (Bell, 1999).

In a similar study on the LINCS professional development model for middle school teachers of mathematics, Swafford, Jones, Thornton, Stume, and Miller (1999) discovered similar results. Reflective writing on their experiences in the program was found to be a mediating factor in increasing the teachers' confidence regarding mathematics and mathematics teaching. Additionally, the reflective writing, couched in the context of the professional development program, was found to be a factor influencing whether the teachers moved away from more computational, textbook oriented instruction toward more hands-on, problem-based instruction.

Bandura's ideas of self-efficacy, self-regulation beliefs and behaviors, affect one's confidence to accomplish that which one sets out to do. Teachers' beliefs in their personal ability to motivate and promote learning affect the types of learning environments they create and support (Bandura, 1993, 1997).

If high quality science instruction, by knowledgeable teachers, that promotes complex problem-solving, advanced skills in comprehension, reasoning, experimentation, and communication is to begin early, then elementary teachers must believe that they can teach science and that their students can learn science (Bell, 1999; Downing & Filer, 1999). Reflective journal writing in inquiry-based science courses can be added to the instructional leadership tool kit as a method of positive influence on elementary pre-service teachers' beliefs and attitudes about science and science teaching.

THEORETICAL FRAMEWORK

The Reflective Judgment Framework (RJF), a developmental model describing the changing patterns of reasoning over a person's life-span relies upon measures of individual thinking about ill-defined problems for which there are more than one correct answer (Carr, 1997; King & Kitchener, 1994). The RJF model provided a theoretical framework for investigating undergraduate astronomy students' shifts in reflective judgment in the context of a restructured course that was "lecture-free, problem-centered, and collaborative in structure" (Carr, 1997). Reflective writing was pervasive throughout the course assignments. Carr describes reflective knowing as a process of inquiry....one in which the knower moves from knowing as a result of "hearing from authority" to knowing as a result of "forming one's own opinion" through constructing understanding through one's own investigations, experiences, and

evaluations. Additionally, it provided a way to capture students' projections about their future science teaching attitudes and practices.

Chambers & Stacey (1999) observed that the most successful teacher education students are those who, early in their studies, can make connections between their current learning experiences and future applications when they are in the field. Authentic tasks and scenarios in undergraduate experiences, which purposefully project students into their future roles as teachers, will enhance their understanding of and expertise with the education enterprise (Chambers & Stacey, 1999; Key, 1998). Once they are in the classroom, both during their student teaching experiences and eventually as certified teachers, their bases of knowledge and frameworks will give them confidence to teach inquiry-based science to elementary children.

SIGNIFICANCE

In a medium sized university in the southwest part of the United States a new integrated science course was recently incorporated into the required degree plan for all elementary education majors. The course was implemented to enhance students' content knowledge and to help prepare them for the science domain of the state teaching certification test. Students generally take this upper division course shortly before their internship (first semester) of student field experience. The first offering of this course involved two combined sections co- taught by a physics Ph.D. and a science education Ph.D. The course differed significantly from traditional lecture/textbook type science courses. There was heavy emphasis on active learning with little lecture. Student learning relied heavily upon manipulation of materials, concepts, and ideas and the integration of mathematics in measurement, data collection, and communication of knowledge. Active discussion among and between the students and between the students and the professors provided immediate feedback and clarification of understandings. During this study

about 10% to 15% of class time and requirements were devoted to issues in science education, the nature of science, and science teaching standards. The students kept daily reflection journals. They reacted to statements taken from Project 2061 Science for All Americans, the National Science Education Standards (NSES), and the TEKS, the state teaching standards. In their reflections they made connections among/between the reaction statements, their personal experiences and beliefs, and the state teaching standards.

This study was done in only one semester during which the instructors attempted to provide a positive, supportive learning environment. The students were actively engaged in interacting with scientific ideas and phenomena and were able to interact and discuss their understandings with each other and with the instructors. On the one hand these factors might be considered delimiting in a study focused on reflective journal writing and present a threat to internal validity. However, the MSEC study, the LINCS study, the Chambers and Lacey study, and the Reflective Judgment Framework model all suggest that reflective writing is a component of a larger complex of factors that operate together to influence changed attitudes and teaching practices. Similar studies of cohorts in similar learning contexts from other semesters may confirm or disconfirm this study.

Two sections (n=65 students) of the Integrated Science course were combined and co-taught by a physics Ph.D. and an elementary education professor with a science education Ph.D. The physics instructor taught the physical science topics, which were the main focus of the science content. The elementary education instructor was responsible for the earth science and life science concepts. Both instructors took responsibility for conducting and managing the journal writing activities with the main responsibility taken by the elementary education instructor.

All 65 students were given the opportunity to participate in the study. Of these (n=37) agreed to have their STEBI-B surveys, their journal writings, and other data used for this study. During the next semester, of the 37 participants, five were assigned to the field-based teaching center where the elementary education instructor supervised pre-service teachers and taught a science methods seminar to the interns.

Students in the Integrated Science course were required to write a reflection after each class meeting. At the beginning of each class, the students wrote the reflection statement in their journals. Before the next class meeting, based on their class experiences and personal experiences and beliefs, they wrote their reflections and made connections among the statements, their reflections, and state science teaching standards. Several methods such as small group discussions in class, large group discussions led by small groups in class, and written responses in the journals by a professor were used for giving students feedback on their reflections. The professor's comments were either affirmations of the connections students made with cogent thinking or probing questions to cause the students to think further. The grade for the journals was dependent on the percentage of journals completed and elaboration of responses.

Data regarding the field-experiences of the pre-service teachers' inquiry teaching came from observations, copies of lesson plans, and discussion with the students and their mentors.

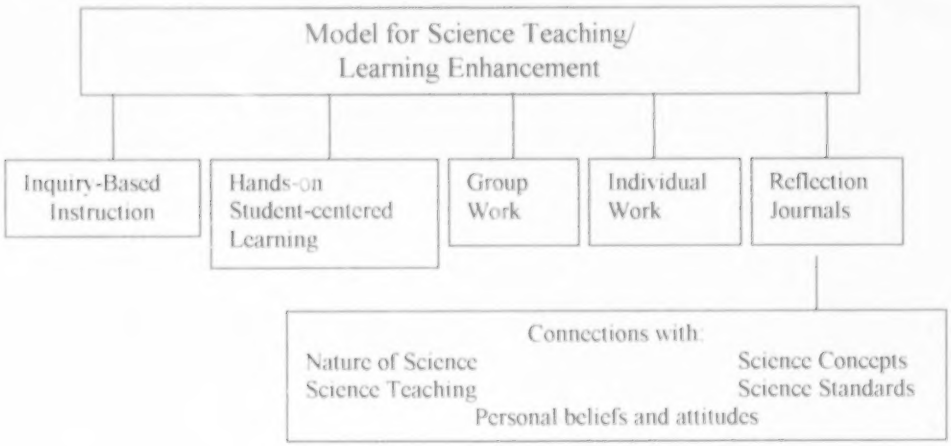
Cross-case and pre/post case analysis was used to analyze emergent themes in students reflection journals. These themes included student perceptions about science, about their ability to teach science, and their beliefs about who can learn science.

FINDINGS

The course design was developed along educational change models advocated by the NSES and NCTM standards. (See Table 1). The focus of this exploratory study was on the

reflective writing component in the context of inquiry-based learning experiences of pre-service elementary teachers in an Integrated Science course.

Table 1. Integrated Science Course Structure



The journal responses from the 37 participants in the study indicated that the differences between elementary science learning experiences of the youngest students and of the oldest students were not significantly different. The youngest students were 20 years old and the oldest students were in their early 40's. In general, the students' reflections showed that their personal experiences in elementary science were fairly typical of what is known about elementary science teaching.

"Science was cut and dried (textbook learning)"

"I don't remember having science until about 6th or 7th grade."

Beliefs and attitudes indicated by some of the students' writings at the beginning of the semester were:

"I thought it wasn't possible to teach science in the elementary grades... it would be too hard for the elementary students..."
"Science is difficult and confusing."
"I am worried and scared about taking this course."

Although a limited number of students had positive memories of elementary science learning experiences and maintained those throughout the course, journal writings at the end of the semester indicated changed beliefs and attitudes among most of the participants in the study.

Students were asked to make connections between the Reaction Statements and the state science teaching competencies. See Table 2 for examples of the state teaching competencies.

Table 2 Examples of State Science Teaching Competencies (Condensed Version)

Higher Order Thinking – The elementary teacher understands, applies, and encourages higher-order thinking skills in the sciences. Basic Science Concepts – … understands basic concepts of the life, earth, and physical sciences and applies these concepts to interpret and analyze phenomena and to plan instruction. Process skill. …understands process skills used to gather and organize data in the life, earth, and physical sciences and applies this knowledge to explore and describe objects, organisms, and events in the environment Intra-and interdisciplinary learning. …demonstrates and understanding of how the life, earth, and physical sciences relate to one another, to other disciplines, and to daily life. *(There are six others relating to laboratory and instructional materials, measurement, safety, communication, and experimental design.)*

Journal Assignment #1 was given to the students at the beginning of the semester to assess their perceptions about science and science teaching. At the end of the semester Journal Assignment #14 was assigned so comparisons could be made across-case and pre/post instruction. The major themes that emerged are given below. Individual's pre and post responses were paired.

Journal Assignment #1:

"Even when the official curricula prescribed the teaching of science, it was not taught regularly or effectively in many elementary classrooms." Schoenberger and Russell (1986)

Journal Assignment #14

Reflect on your perception of science and elementary science teaching. Compare your beliefs at the beginning of the semester to your beliefs today.

Attributes personal anxiety toward science to personal science learning experiences.

Pre *"At the beginning of semester I was not interested in science at all."*
"Wish my teacher had taught science more would have improved my attitude."
"If someone had taken the time to put more effort into the science lessons I was taught, I would have a better memory of what I was taught."
"...felt intimidated by 'theories, laws', thought it was about chemicals, theories, atoms, etc."

Post *"The instructors*(in the IS course*) made science seem not so difficult and complex."*
"I'm more likely to have fun teaching science because of the experiments we have done in class.
"The activities we did in class facilitated my understanding of science concepts."

Attitude toward science.

Pre *"...didn't understand why science was taught because it seemed boring and not a very good use of time."*
"...thought science was dumb and boring and did not want to take this course."
"...science was hard and not very interesting."
"...before this class, did not believe science could be fun for students or teachers."
"I always thought science was interesting."

Post *"I learned a lot about science* (content*) in this course.*
"Taking this class raised my confidence to succeed in this science class."
"I have experienced personal growth during this semester."
"With organization, science can be fun for the teacher and the students.
"I still think science is interesting, important, and fun."

Attitude toward science teaching.

Pre *"...had no idea how to teach science."*
"...didn't feel adequately prepared to teach science to elementary children."
"...was anxious about teaching science because I felt insecure in my personal knowledge of science."

Post *"I am anxious* (wants to) *to teach science."*
"Teaching elementary science will be fun."
"Science can be integrated into and with other content."

Attitude toward science instruction for elementary students.

Pre "*...thought is wasn't possible to teach science in the elementary grades (too hard to grasp)*"
"*...thought science wasn't important for elementary level students.*"
"*...science seemed not important during elementary years, something to be squeezed in* (into the schedule), *science is time consuming.*"

Post "*...want my students to have memorable experiences in science*"
"*I will make science important.*"
"*I believe science should be a vital part of learning.*"
"*I believe that learning science in-depth, over time will improve student learning retention.*
"*Students will have a more sound base for critical thinking.*"

By the end of the semester, the changes in attitude most often indicated by the students were that they believed science could be fun, interesting to both students and teachers, that science should be an important part of elementary students' learning experiences because it extends their scientific thinking, increases their ability to engage in critical thinking, and that science is related to everyone's daily lives.

The most pervasive changes regarding their personal knowledge was that the experiences in class increased their own science content knowledge and that they felt more confident to modify lessons done in class for kindergarten through eighth grade students. They indicated more confidence to accept the nature of scientific inquiry and how to handle the class when experiments don't turn out as expected. Some changed their views of science as a distant, technical domain that didn't have much to do with their daily lives toward an understanding that science is plants, animals, fun labs, and has much to do with everyday life.

The final journal reflections indicated that most of the students understood how science teaching and learning relates to all the state teaching competencies, that science learning can improve students' problem-solving ability, that the better prepared and more knowledgeable teachers are the better they can teach science to young children. Some students had a concern

about science instruction interfering with preparation of elementary students for the state accountability testing. The integrated nature of this course helped them to understand how science is related across disciplines and can be integrated with other content areas. Some were able to understand how student learning competencies from other disciplines could be taught in a more interesting and meaningful way through science.

The five interns' use of inquiry was demonstrated through lesson plan design, discussion with the pre-service instructor, and with their mentor in-service teachers, and through lesson observations. Their lessons involved engagement of their elementary students in model building, hands-on activities, discussion, data collection, and communication of findings and interpretations. Communication occurred through various methods such as orally, the use of charts and graphs, posters, and written summaries and/or reports.

An overview of the findings of the Personal Science Teaching Efficacy Beliefs scale PSTE and the Science Teaching Outcomes Beliefs STOE scores from the pre/post STEBI-B administration are shown in Table 3. Approximately half the questions on the STEBI-B concern current beliefs and attitudes and approximately half concern predictions of future abilities and attitudes of pre-service teachers, Enochs and Riggs (1990)

Table 3. Results of STEBI-B

Scale	Pre-Course Mean	Post-Course Mean
PSTE	49.60	49.99
STOE	35.38	35.43

Although the quantitative data indicates only slight differences, the qualitative data from individual students' reflection journals indicate a more significant and more pervasive change. This is further supported by classroom observations and discussion with a small, representative group of intern teachers and their mentors. It is possible that the quanitative instrument is not

sensitive enough to accurately measure the small number of responses in this study, particularly since two of the 37 participants were highly motivated science learners from the beginning to the end of the semester.

CONCLUSION AND DISCUSSION

The results of this study support the notion that reflective journal writing can have an effect on changed beliefs and attitudes elementary pre-service teachers hold toward science and science teaching. Reflective writing in the context of a supportive environment of inquiry-based instruction in science provides the opportunity for pre-service teachers to contemplate their beliefs about their own competency and understanding about science and science teaching. In addition, reflective writing can aid pre-service teachers in developing a belief pattern about science and science learning that is more in line with the Benchmarks, the NSES standards, and with state teaching and learning standards.

Science instructors in higher education have several tools that may influence pre-service teachers' attitudes and beliefs regarding science and science teaching. Among these are assessing students pre-conceptions about science and scientists by administering the Draw-A-Scientist assessment, providing students opportunities to actively engage and grapple with scientific phenomena, demonstrating (on the part of the instructors) a positive, supportive attitude toward the pre-service teachers' science learning experiences, and demonstrating to the pre-service teachers methods they can use to teach science in the elementary classroom.

This study suggests that reflective writing about science and science teaching in the context of learning science content, process skills, and pedagogical skills is a valuable teaching/learning tool. An important aspect of reflective journal writing is that there can be more than one correct analysis as students make connections among their own experiences and beliefs,

issues in science, and their roles as future teachers of elementary science. As Chambers & Stacey (1999) and Key (1998) found the most successful teacher education students are those who can make connections between their own current learning experiences and develop an image of themselves in their future roles as science teachers.

Instructional leadership roles established by collaborations between and among natural science departments and education departments can result in course designs that enhance elementary pre-service teachers' attitudes about science and their eventual science teaching practices. Science learning experiences at the undergraduate level that incorporate innovative means such as reflective journal writing of influencing pre-service teachers toward positive attitudes and beliefs about science and science teaching can result in science being taught more frequently to a more diverse group of elementary science learners.

BIBLIOGRAPHY

Bandura, A. (1997). Self-efficacy: The exercise of control. NY: W. H. Freeman.

Bandura, A. (1993). Perceived self-efficacy in cognitive development and functioning. Educational Psychologist, 28 (2), 117-148.

Bell, G.L. (1999). An investigation of a professional development model in science education: A systems approach. (Doctoral dissertation, The University of Texas-Austin, 1999). UMI Dissertation Services, 9947171.

Bell, G.L & Eaton, R. L. J. (2000). Paper presented at the annual meeting of the National Association for Research in Science Teaching, Akron, OH (January 8, 2000).

Carr, K.M. (1997). A constructivist approach to reflective judgment and science literacy in introductory college science instruction. Paper presented at the Annual Meeting of the Northern Rocky Mountain Educational Research Association (15th, Jackson, WY, October 3, 1997)

Centre for Academic Practice. Reflective Journal Guidance Notes. The University of Warwick, United Kingdom. Available at: http://www.warwick.ac.uk/services/CAP/Tea...pport/Guidance_Notes/Journal/journal.html

Chambers, D.P. & Stacey, K. (1999). Authentic tasks for authentic learning: Modes of interactivity in multimedia for undergraduate teacher education. 7 p. In: SITE 99: Society for Information Technology & Technology Teacher Education International Conference (10th, San Antonio, TX, February- March, 1999)

Commission on Standards for School Mathematics. (1989). National Standards for School Mathematics. Reston, VA: National Council of Teachers of Mathematics.

David, J.L. (1994) Realizing the promise of technology: The need for systemic education reform. Systemic Reform: Perspectives on Personalizing Education. Internet. Available: http://inet.ed.gov/pubs/EDReformStudies/SysReforms/david1.html

Downing, J.E. & Filer, J.D. (Fall,1999). Science process skills and attitudes of pre-service elementary teachers. Journal of Elementary Science Education 11(2), 57-64.

Enochs, L. G. & Riggs, I. M. (1990). Further development of an elementary science teaching efficacy belief instrument: A pre-service scale. School Science and Mathematics, 9(8), 694 - 706.

Ericsson, K.A. and Charness, N. (1994). Expert performance. American Psychologist. 725 – 747.

Ginns, I. S. & Watters, J. J. (1998, April). Beginning Teachers' Professional Growth Confronting the Challenge of Teaching Elementary School Science. Paper presented at the Annual Meeting of the American Educational Research Association, San Diego, CA.

Ginns, I. S., Watters, J. J., Tulip, D. F. & Lucas, K. B. (1995). Changes in pre-service elementary teachers' sense of efficacy in teaching science. School Science and Mathematics, 95(8), 394 - 400.

Herman, J.L. (1994) Evaluating the effects of technology in school reform in B. Means (Ed.), Technology and Education Reform The Reality Behind the Promise (pp. 133 - 168). San Francisco: Jossey-Bass Publishers.

Key, D.L. (1998). Teacher interns' changing perceptions during internship. Paper presented at the Annual Meeting of the Mid-South Educational Research Association. (New Orleans, LA, November, 1998)

King, P. & Kitchener, K. (1994). Developing Reflective Judgment. San Francisco: Jossey-Bass Publishers.

Means, B., Blando, J., Olson, K., Middleton, T., Morroco, C. C., Remz, A. R., & Zorfass, J. (1992). Using technology to support education reform. Available at: http://pride.soe.uaa.alaska.edu/www/SOE/ed626readings/SRI/title.html

National Research Council (NRC). (1995). National science education standards. Washington, DC: National Academy Press.

Pogrow, S. (1991). Challenging at-risk students: Findings from the HOTS program. Phi Delta Kappan, 71(5), 389-397.

Project 2061: American Association for the Advancement of Science. (1990). Science for all Americans. NYNY: Oxford University Press.

Project 2061: American Association for the Advancement of Science. (1993). Benchmarks for science literacy. NYNY: Oxford University Press.

Swafford, J.O., Jones, G.A., Thornton, C.A., Stump, S.L., & Miller, D.R. (1999). The impact on instructional practice of a teacher change model. Journal of Research and Development in Education, 32(2), 69-52.

Schoeneberger, M., & Russell, T. (1986). Elementary science as a little added frill: A report of two case studies. Science Education, 70, 519-538.

Thomas, J.A., Pedersen, J.E., & Bonstetter, R. (1998). Experience is the best teacher: A study of episodic memory in science teacher preparation. Paper presented at the Annual International Meeting of the Association for the Education of Teachers in Science, Austin, TX.